

**We claim:**

1. A method of preparing a parametric speaker transducer for (i) generating sonic or subsonic audio output by propagating two frequencies having a difference in value  
5 equal to the desired sonic or subsonic audio output and (ii) decoupling the two frequencies to generate the desired audio output, the method comprising the steps of:

a. positioning an electrically sensitive, mechanically responsive film over at least one closed-end cavity of a rigid support member within a pressure chamber;

10 b. applying a pressure differential within the chamber to provide a common cavity pressure substantially different from ambient pressure;

c. sealing the film to the support member while within the pressure chamber to capture the cavity pressure in a permanent configuration; and

15 d. removing the sealed film and support member from the pressure chamber, thereby distending the film into an arcuate emitter configuration with respect to the at least one cavity in response to a pressure differential between cavity pressure and ambient pressure on opposing sides of the film to enable constricting and extending of the emitter configuration in response to variations in an applied electrical input at the piezoelectric film to thereby create a compression  
20 wave in a surrounding environment.

2. A method for emitting subsonic, sonic or ultrasonic compression waves, said method comprising the steps of:

a. positioning a piezoelectric film over at least one closed-end cavity within a rigid support member, said support member having an outer face formed  
25 around the at least one cavity;

b. distending the piezoelectric film into an arcuate emitter configuration with respect to the at least one cavity in response to a pressure differential between cavity pressure and ambient pressure on opposing sides of the film to enable constricting and extending of the emitter configuration in response to  
30 variations in an applied electrical input at the piezoelectric film to thereby create a compression wave in a surrounding environment; and

c. applying electrical input to the piezoelectric film to propagate a desired compression wave.

3. A method as defined in claim 2, wherein the step of distending the film into the arcuate emitter configuration comprises the more specific steps of:

a. positioning the support member and the piezoelectric film within a chamber having a chamber pressure at a substantial pressure differential with respect to ambient pressure;

b. sealing the film to the outer face of the support member while in the chamber to capture the chamber pressure within the at least one cavity; and

c. removing the support member and sealed film from the chamber to an ambient pressure environment to thereby distend the film into the arcuate configuration with respect to the at least one cavity.

4. A method as defined in claim 3, comprising the more specific step of developing a negative pressure within the chamber, thereby creating a negative cavity pressure to distend the film into the arcuate configuration within the at least one cavity.

5. A method as defined in claim 4, wherein the negative pressure approximately corresponds to a vacuum.

6. A method as defined in claim 3, comprising the more specific step of developing a positive pressure within the chamber, thereby creating a positive cavity pressure to distend the film into the arcuate configuration away from the at least one cavity.

7. A method as defined in claim 3, comprising the more specific step of positioning the support member and the piezoelectric film in a spatially separated configuration within the chamber having a chamber pressure at a substantial pressure differential with respect to ambient pressure.

8. A method for emitting subsonic, sonic or ultrasonic compression waves, said method comprising the steps of:

a. positioning a piezoelectric film over an array of closed-end cavities formed within a rigid support member, said support member having an outer face formed around the array of cavities;

b. distending the piezoelectric film into an arcuate emitter configuration with respect to the cavities in response to a pressure differential between cavity pressure and ambient pressure on opposing sides of the film to enable constricting and extending of the emitter configuration in response to variations in an applied

electrical input at the piezoelectric film to thereby create a compression wave in a surrounding environment; and

c. applying an electrical input to the piezoelectric film to propagate a desired compression wave.

5           9. A method as defined in claim 8, wherein the step of distending the film into an arcuate emitter configuration comprises the more specific steps of:

a. positioning the support member and the piezoelectric film within a chamber having a chamber pressure at a substantial pressure differential with respect to ambient pressure;

10           b. sealing the film to the outer face of the support member while in the chamber to capture the chamber pressure within the cavities; and

c. removing the support member and sealed film from the chamber to an ambient pressure environment to thereby distend the film into the arcuate configuration with respect to the cavities.

15           10. A method as defined in claim 9, comprising the more specific step developing a negative pressure within the chamber, thereby creating a negative cavity pressure to distend the film into the arcuate configuration within the at least one cavity.

20           11. A method as defined in claim 9, comprising the more specific step of positioning the support member and the piezoelectric film in a spatially separated configuration within the chamber having a chamber pressure at a substantial pressure differential with respect to ambient pressure.

12. A method as defined in claim 1, further comprising the step of forming the at least one cavity in a circular configuration.

25           13. A method as defined in claim 1, further comprising the step of forming the at least one cavity in an elliptical configuration.

14. A method as defined in claim 1, further comprising the step of forming the at least one cavity in an elongated slot configuration.

15. A method as defined in claim 1, further comprising the step of forming the at least one cavity in a serpentine configuration.

30           16. A method as defined in claim 1, further comprising the step of forming the at least one cavity in a spiral configuration.

17. A method as defined in claim 1, further comprising the step of forming the at least one cavity as an array of cavities forming a concentric configuration of rings.

18. A method as defined in claim 1, wherein the step of applying an electrical input comprises the more specific step of applying an ultrasonic parametric signal capable of decoupling when emitted in air to generate a sonic compression wave as part of a parametric speaker system.

5           19. A method as defined in claim 18, further comprising the step of optimizing the cavity configuration to have a resonant frequency coordinated with a carrier frequency of the ultrasonic parametric signal.

20. A method as defined in claim 1, comprising the more specific steps of:

10           a. positioning piezoelectric film over opposing closed-end cavities on opposing sides of and within a single rigid support member;

            b. distending the piezoelectric film into an arcuate emitter configuration with respect to the opposing cavities in response to a pressure differential between cavity pressure and ambient pressure on opposing sides of the film at each cavity to enable constricting and extending of the emitter configuration in response to variations in an applied electrical input at the piezoelectric film to thereby create opposing compression waves in a surrounding environment; and

15           c. applying electrical input to the piezoelectric film to propagate the desired compression waves in opposing directions.

20           21. A method as defined in claim 20, wherein the step of distending the film into the arcuate emitter configuration comprises the more specific steps of:

            a. positioning the support member and the piezoelectric film within a chamber having a chamber pressure at a substantial pressure differential with respect to ambient pressure;

25           b. sealing the film to opposing outer faces of the support member while in the chamber to capture the chamber pressure within the opposing cavities on each face of the support member; and

            c. removing the support member and sealed film from the chamber to an ambient pressure environment to thereby distend the film into the arcuate configuration with respect to the cavities.

30           22. A method as defined in claim 20, further comprising the steps of forming apertures in the support member with terminal openings exposed on opposing sides of the support member and applying the film over opposing sides of the support member to form the closed-end cavities over respective ends of the apertures.

23. A method as defined in claim 1, wherein the step of distending the film into the arcuate emitter configuration comprises the more specific steps of:

- 5           a. positioning the piezoelectric film on the support member prior to placement within a the pressure chamber and modifying chamber pressure to a substantial pressure differential with respect to ambient pressure;
- b. sealing the film to the outer face of the support member while in the chamber to capture the modified chamber pressure within the at least one cavity; and
- 10          c. removing the support member and sealed film from the chamber to an ambient pressure environment to thereby distend the film into the arcuate configuration with respect to the at least one cavity.

24. A method as defined in claim 2, further comprising the applying heat to the film after sealing at the support member.

15          25. A method as defined in claim 2, wherein the method of applying electrical signal is accomplished as part of a parametric sound emitter configured for generating near-field applications of sonic energy for direct exposure to listeners

20          26. A method as defined in claim 2, wherein the method of applying electrical signal is accomplished as part of a parametric sound emitter configured for generating far-field applications of sonic energy for indirect exposure to listeners by way of a virtual speaker location at a reflective surface.

27. A method as defined in claim 2, further comprising the step of directing the output of the emitter with low frequency emissions directly at an individual for physically disabling the individual.

25          28. A method as defined in claim 1, comprising the more specific step of forming the closed-end cavity as a depression extending within but not through the support member.

29. A method as defined in claim 1, comprising the more specific step of forming the closed-end cavity as a combination of at least one aperture through the support member communicating to an otherwise closed plenum chamber

30          30. A method of forming protuberances in piezoelectric material as a parametric emitter for an acoustic device, said method comprising the steps of:

- a. providing a substrate having a plurality of closed-end cavities of a given dimension formed therein;

b. forming a laminate comprising a film of polymer piezoelectric material sandwiched between a first electrode layer on a top surface and a second electrode layer on a bottom surface of the polymer material;

5 c. positioning the substrate and the laminate within a low pressure environment;

d. securing the laminate to the substrate within the low pressure environment to form a sealed composite assembly which captures a low pressure state within the cavity between the substrate and the laminate; and

10 e. positioning the composite assembly in an ambient pressure environment to form protuberances in the film at the locations of the perforations.

31. The method of claim 30 further comprising the step of applying heat to the substructure and bonded piezoelectric film to accelerate the plurality of arcuate configurations to distend to a level of substantial stasis.

15 32. The method of claim 30 further comprising the step of applying heat to the substructure and bonded piezoelectric film to accelerate the bonding of the piezoelectric film to the substructure.

33. The method of claim 30 further comprising the step of sizing the plurality of cavities to form a resonance at a predetermined frequency.

20 34. The method of claim 30 further comprising the step of forming electrical connectivity to the first electrode layer of the piezoelectric film and the second electrode layer of the piezoelectric film for coupling to an electrical signal source.

35. A method as defined in claim 30, further comprising the steps

25 a. providing a second emitter substructure having an outer face oriented outward in a different direction than the outer face of the first substructure and having a plurality of closed-end cavities formed thereon;

b. providing a second piezoelectric film with a first conductive side and a second conductive side with the second film prepared to be adhered at the second side to the second substructure outer face;

30 c. placing the first and second piezoelectric films and the first and second emitter substructures in a vacuum chamber and substantially evacuating the air from the vacuum chamber;

d. bonding the first and second piezoelectric films to outer faces of the first and second substructures within the evacuated vacuum chamber to capture a low pressure condition in the cavities enclosed by the films and substructures;

e. removing the substructures and bonded piezoelectric films to be exposed to the external environment to allow atmospheric pressure to distend the piezoelectric thin films into concave arcuate configurations over the cavities; and

f. applying electrical input to both the first and second films to simultaneously generate compression waves in two different directions.

36. A method for constructing a piezoelectric emitter comprising:

a. providing an emitter substructure having at least one outer face having a closed-end cavity formed thereon;

b. providing a piezoelectric film with a first conductive side and a second conductive side with the film prepared to be attached to the substructure outer face;

c. placing the piezoelectric film and the emitter substructure in a vacuum chamber and substantially evacuating the air from the vacuum chamber;

d. bonding the piezoelectric film to at least one outer face of the substructure with the vacuum chamber in a low pressure state;

e. removing the substructure and bonded piezoelectric film to be exposed to the external environment to allow atmospheric pressure to distend the piezoelectric thin film into a concave arcuate region over the area of the cavity.

37. A method for constructing a piezoelectric emitter comprising:

a. providing an emitter plate having at least one outer face oriented outward and at least one inner face with at least one cavity extending between the outer and inner faces;

b. positioning a back cover against the inner face of the emitter plate to form a closed-cavity with the inner face being sealed off in relationship with the external environment;

c. providing a piezoelectric film with a first conductive side and a second conductive side with the film prepared to be attached to the emitter plate outer face;

d. placing the piezoelectric film and the emitter plate in a vacuum chamber and substantially evacuating the air from the vacuum chamber to a low pressure state;

e. bonding the piezoelectric film to outer face of the emitter plate to seal the cavity with a cavity pressure at the low pressure state;

f. removing the substructure and bonded piezoelectric film to be exposed to the external environment to allow atmospheric pressure to distend the piezoelectric thin film into a concave arcuate region over the area of the cavity.

38. An ultrasonic transducer apparatus comprising:

a substrate having an array of closed-end cavities including an open side respectively formed therein at predetermined positions on the substrate such that the array forms a given area within the substrate;

a layer of polymeric piezoelectric material with opposing conductive sides and being disposed on the substrate to seal the open side of the cavities, the layer of piezoelectric material having a plurality of protuberances each being defined by a respective portion of the piezoelectric material extending into a corresponding one of the closed-end cavities, the plurality of protuberances being substantially permanently formed by a pressure differential existing between the sealed cavity and ambient room pressure and defining an active area of the transducer corresponding to the given area of the substrate; wherein a resonance frequency of the transducer is a function of a shape of the protuberances as determined by at least one dimension of the cavities, and wherein a vertical and horizontal beam angle associated with the transducer is controllable as a function of the dimensions of the active area of the transducer.

39. A flat ultrasonic transducer comprising:

a substrate having a plurality of closed-end cavities formed therein;

a layer of polymeric piezoelectric material disposed on the substrate, the layer of piezoelectric material including a plurality of protuberances defined by portions of the piezoelectric material extending into corresponding ones of the cavities in response to a pressure differential existing between pressure within the cavities and ambient room pressure, the plurality of protuberances defining an active area of the transducer; wherein the resonance frequency of the transducer is a function of a curvature of each of the protuberances as determined by at least



one dimension of the cavities, and wherein the output power is controllable as a function of the ratio of the active area to the total substrate area.

40. A transducer comprising:

a substrate having a plurality of closed-end cavities formed therein;

5 a layer of polymeric piezoelectric material disposed along the substrate, the layer of piezoelectric material including a plurality of protuberances of a given curvature, the protuberances each being defined by portions of the piezoelectric material extending into a corresponding one of the closed-end cavities in response to a pressure differential between the cavity pressure and ambient room pressure,  
10 the plurality of protuberances defining an active area of the transducer;

contact means coupled to the piezoelectric material for providing an electrical input to cause vibration of said protuberances at a predetermined frequency which is independent of the radius of curvature of the substrate.

41. An ultrasonic transducer assembly comprising:

15 an ultrasound transducer including:

a substrate including top and bottom surfaces, the substrate including a conductive material at the top surface and including a plurality of closed-end cavities formed therein;

20 a laminate comprising a film of a polymer piezoelectric material sandwiched between a first electrode layer on a top surface and a second electrode layer on a bottom surface, the laminate disposed on the top surface of the substrate, the laminate including a plurality of protuberances each of a given curvature and respectively extending into a corresponding one of the closed-end cavities based on a pressure differential existing  
25 between cavity pressure and ambient pressure; and

a housing containing the ultrasound transducer, the housing including an open end and a closed end, the housing comprising:

a first contact in electrical communication with the first electrode layer;

30 a second contact in electrical communication with the second electrode layer;

means coupled to the first contact for providing a first electrical connection through the closed end to provide a first terminal for connection to a first electrical potential; and

means coupled to the second contact for providing a second electrical connection through the closed end to provide a second terminal for connection to a second electrical potential; whereby the substrate is operative to provide mechanical protection to the transducer laminate and to electrically couple the first and second electrode layers each to a corresponding terminal.

42. A speaker device for emitting subsonic, sonic or ultrasonic compression waves, said device being comprised of:

a rigid emitter support member having an outer face that includes at least one closed-end cavity with a single exposed opening at the outer face of the support member;

a thin piezoelectric film disposed across and sealed to the outer face of the emitter support member, said film being distended into an arcuate emitter configuration with respect to the at least one cavity in response to a pressure differential between cavity pressure and ambient pressure on opposing sides of the film;

said film being capable of constricting and extending in response to variations in an applied electrical input to thereby create a compression wave in a surrounding environment.

43. A speaker device for emitting subsonic, sonic or ultrasonic energy waves, the device being comprised of:

an emitter substructure having at least one outer face oriented outward;  
the emitter substructure having a plurality of cavities on the outer face of the emitter substructure;

a thin piezoelectric film disposed across the cavities of the emitter plate in a substantially sealed off relationship relative to the external environment;

electrical contacts coupled to the piezoelectric film for providing an applied electrical input;

a pressure differential applied between the configurations of cavities and the external environment for developing a biasing pressure with respect to the thin

film at the cavities to distend the film into an emitter configuration with arcuate configurations capable of constricting and extending in response to variations in the applied electrical input at the piezoelectric film to thereby create an energy wave in a surrounding environment.

5           44. The speaker device in claim 43 wherein the plurality of cavities are individually circular in shape.

          45. The speaker device in claim 43 wherein the plurality of cavities are individually elliptical in shape.

          46. The speaker device in claim 43 wherein the plurality of cavities include  
10 elongated slot configurations.

          47. The speaker device in claim 43 wherein the plurality of cavities form concentric rings.

          48. The speaker device in claim 43 wherein the plurality of cavities form a spiral.

          49. The speaker device in claim 43 wherein a multiplicity of separate emitter  
15 structures are configured to operate together as a single speaker device.

          50. The speaker device of claim 43 wherein the speaker device is optimized to operate as an ultrasonic emitter for use as a parametric speaker system.

          51. The speaker device of claim 50 wherein the speaker device is optimized to have a resonant frequency that is coordinated with a carrier frequency of the parametric  
20 loudspeaker system.

          52. The speaker device of claim 51 wherein the speaker device is utilized below the resonant frequency in coordination with a parametric loudspeaker operated in lower sideband mode.

          53. The speaker device in claim 43 wherein the emitter substructure is configured  
25 as a flat plate.

          54. The speaker device in claim 43 wherein the emitter substructure is configured as a convex curved plate.

          55. The speaker device in claim 43 wherein the emitter substructure is configured as a concave curved plate.

          56. The speaker device in claim 43 wherein the emitter substructure is configured  
30 as a cylindrical device.

          57. The speaker device in claim 43 wherein the emitter substructure has at least a second outer face oriented outward in a different direction from the first outer face and

including at least one closed-end cavity therein, and the thin piezoelectric film is also disposed across the second outer face, said film being distended into an arcuate emitter configuration with respect to the at least one cavity in response to a pressure differential between cavity pressure and ambient pressure on opposing sides of the film, the emitter substructure being configured as a bidirectional device projecting sound in at least two different directions.

58. A speaker device for emitting subsonic, sonic or ultrasonic energy waves, the device being comprised of:

an emitter substructure having at least one outer face oriented outward, the emitter substructure having at least one closed-cavity on the outer face of the emitter substructure;

a thin piezoelectric film disposed across the cavity of the emitter plate in a substantially sealed off relationship relative to the external environment;

electrical contacts coupled to the piezoelectric film for providing an applied electrical input;

a pressure differential applied between the cavity and the external environment for developing a biasing pressure with respect to the thin film at the cavity to distend the film into an emitter configuration with an arcuate region capable of constricting and extending in response to variations in the applied electrical input at the piezoelectric film to thereby create an energy wave in a surrounding environment.

59. A method for indirectly propagating parametric sound a predetermined distance as part of a parametric sound system; the method comprising the steps of:

a) selecting an approximate limiting distance for which parametric sound is to be propagated such that beyond the limiting distance sound pressure level is nominal;

b) identifying a maximum sound pressure level at which the parametric sound system is to be operated;

c) selecting an ultrasonic carrier frequency for the parametric sound system that is sufficiently high so that propagated ultrasonic output of the sound system is sufficiently attenuated within the selected limited distance to limit propagation of the parametric sound to nominal levels beyond the limiting distance; and

d) operating the parametric sound system at the selected ultrasonic carrier frequency and approximately at or below the identified maximum sound pressure level.

5 60. A method as defined in claim 59, further applied as part of an audio broadcasting system for use in an environment where transient persons can receive broadcast information only when in direct proximity to the parametric sound system, said method comprising the steps of:

- a) positioning the parametric sound system along an intended traffic area for transient persons;
- 10 b) orienting propagation of the parametric sound toward a region of intended exposure of the transient persons;
- c) activating the parametric sound system as persons move toward the region of intended exposure; and
- 15 d) propagating the broadcast information to the transient persons as they pass through the region.